INDUSTRIAL HYGIENE SECTION

This Industrial Hygiene Section is published to promote sound thought upon and concerning industrial hygiene. To that end it will contain articles, discussions, news items, reports, digests, and other presentations, together with editorial comments. The editorial policy is to encourage frank discussion. On this basis contributions are invited.

Industrial Medicine

Reg. U. S. Pat. Off.

The Editorial Committee will exercise its best judgment in selecting for publication the material which presents most exactly the factors affecting industrial health and developments for control of potentially injurious exposures. The editors may not concur in opinions expressed by the authors but will endeavor to assure authenticity of fact.

The Science, the Law and the Economics of Industrial Health

Volume 1 **JULY, 1940** **Section 3**

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National Defense and Industrial Hygiene

TODAY'S greatest need in the national defense program and that most difficult to provide is adequate supply of experienced and skilled men. Not only must the present force of skilled men actually carry on their work but in addition it is largely their problem to train new recruits for the industrial ranks. The National Defense Advisory Commission has just announced a program for developing additional skilled labor but only with an effective and intensified endeavor to maintain the health of these workers, can the skills of these men be fully productive.

This Commission states that facilities can be made available for training as many as a million and a half people for skilled industrial pursuits. If a program could be developed which would avoid lost time due to illness, both occupational and non-occupational, there would be added immediately to the number of wage earners engaged in manufacturing industries in this country the equivalent of a third of a million men.

No respecter of persons is this despoiler of man power. Key men in a manufacturing operation may be stricken with a disabling illness just as much as less skilled and more easily replaceable workers. And as key men among this group of a third of a million become disabled through illness, they cause reduction in the amount and quality of work of the men left on the job.

Where a tool dresser for a dozen machine operators becomes ill, it is probable that the substitute will not grind and temper the tools as expertly as the regular man with the consequence that the work of the dozen operators will fall below par. Most plants have utility men who can do a variety of jobs, but when certain utility men are laid up, then additional loss of workers in line production may tie up an operation.

Where an operation essential to the manufacture of a product involves an occupational disease exposure, the situation becomes more serious

than the actual number of workers exposed or those actually disabled would indicate. In the first place, as men become affected by excessive exposure to injurious materials, they tend to slow up before they are actually compelled to leave the job. Then as men either become disabled or seek other employment due to a realization that the operation is affecting their health, training of new skilled workers for such an operation becomes a continuous process. The importance of adequate control of potential hazards at such an operation become even more pronounced during times of national emergency.

With accelerated industrial expansion, the application of accepted methods of protection will require more intensive supervision on the part of the industrial hygienist. There will be a tendency to give a maximum of attention to the production unit at the expense of provision of exhaust ventilation or other means of avoiding liberation of injurious materials. It must be emphasized that maximum production from a manufacturing unit depends upon maximum effectiveness of the personnel handling the unit. Provision of proper work environment is accordingly part and parcel of an effective production program.

Numbers of special problems in industrial hygiene will be presented with the speed-up in production in accordance with the needs of national defense. A new worker may find that there is no discomfort if he forgets to wear personal respiratory protective apparatus and consequently removes such protection when he is not under direct supervision. In the training of new workers, the potential hazards should be fully explained and personal control measures followed up. The fact that protection may be necessary even when there may be no immediate discomfort must be emphasized. The attitude should be avoided whereby one of these new workers is led to believe that he will be considered a tenderfoot unless he can tolerate an excessively irritating condition rather than to bring it to the attention of his foreman.

In addition to new workers, there will also be new processes. One plant engaged in the manufacture of mechanical parts for automobile engines with the principal occupational disease that of dermatitis from cutting oils is confronted with the production of these same parts for airplane engines. The increased precision demanded for this new application occasioned by national defense requirements involved the installation of new cleaning and plating processes which introduced occupational disease exposures necessitating special ventilation and procedural measures.

In still other plants, entirely new products will be manufactured. A brass goods manufacturing plant may find mercury compounds must be incorporated in its products with an attendant mercury poisoning hazard.

The speeding up of production will present new problems arising from fatigue, constructive suggestion for which may permit sustained effort throughout the work-day with new production records. Night shifts will be more frequent, presenting problems in illumination.

All this added industrial load will be carried on by industrial workers whose average physical condition will in all probability be at a lower level than that of the present industrial population. This in itself will make the problem of maintenance of health more difficult.

National defense thus presents a challenge to the industrial hygienist to achieve greater effectiveness in the control of industrial health hazards and in the general raising of worker health levels; and at the same time it presents a much more difficult situation under which to reach this higher peak of accomplishment.

Lead Poisoning Prevention

THE report of the proceedings of the Industrial Hygiene Sessions conducted October 24-25, 1939, by the National Battery Manufacturers Association at their 15th Annual Convention in Chicago has been published and is available through them at Akron, Ohio, at $2.00 a copy.

This Association has taken a real lead in sponsoring a study of the lead exposure in the industry by the United States Public Health Service. Following an introduction by MR. L. B. F. RAYCROFT, the President of the Association, in which he includes a concise, yet comprehensive review of the exact situation together with control measures for prevention of poisoning in such a manner as to be the envy of any full time industrial hygienist, there follows a group of papers on various phases of the subject:

"Discussion of Engineering Problems in Lead Hazard" — J. J. BLOOMFIELD.

"Report of Survey of Lead Hazard in the Storage Battery Industry" -- W. C. DREESEN, M.D.

"Respirators and Respiratory Protection as Applied to the Lead Battery Industry" — W. P. YANT.

"Engineering Phases of Control of Lead Exposure in Small Battery Plants"—WARREN A. COOK.

"Discussion of Recent Studies with Summary of Analytical Results Correlated with Chemical Data and Suggested Methods of Plant Control" — ROBERT A. KEHOE, M.D.

"Experience with Lead Hazard in a Group of Storage Battery Plants" — W. J. MCCONNELL, M.D.

"Lead Poisoning in Small Battery Operations —CAREY P. MCCORD, M.D.

"Adequate Medical Facilities for Control of Lead Absorption" — E. L. BELKNAP, M.D.

"Case History in Compensation Claim for Lead Poisoning" — C. O. SAPPINGTON, M.D., DR.P.H.

"Control of Lead Hazards" — H. H. VALIQUET.

"Special Medical and Engineering Session"—An informal discussion of the medical and engineering phases of lead hazard and preventive and corrective measures in use in several plants.

This brochure is commended to anyone who may have contact with lead or with control of lead poisoning either from the medical or the engineering point of view.

Industrial Hygiene

—*in Steel Plant Practice*—

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STEEL—the sprawling giant of heavy industry—consumes with a ravenous appetite a carefully balanced and varied diet of raw materials, digesting its ration with uncouth rumbling and belching, in order to perform an ever more essential and exacting service for man—its pigmy master. Fortune favored this giant during youth so that it grew vigorously and attained full stature without acquiring conspicuous physical defects or incurably chronic diseases. Since reaching maturity, however, occasional deep-seated twinges of pain have induced steel to test the boasted merits of several nostrums until recently it has turned to health insurance, submitting to a thorough examination in order to determine the risk involved. Let us inspect this examination to form an estimate of the proper premium to be charged.

Temperature Effects

STEEL is bothered with several afflictions, the most annoying of which is its fickle temperature. Dublin and Vane have pointed out that iron and steel mill workers are among the first five to seventy-two occupations studied in the order of frequency from influenza, pneumonia and other diseases, of the respiratory system. The United States Public Health Service in Bulletin 202 has estimated that there are nearly 700 more cases of pneumonia each year among iron and steel workers than in an equal number of men employed in other industries. Among occupations involving exposure to inclement weather or wide temperature variations, the frequency of pneumonia is over three times that in trades without this potential hazard. Marked changes in skin temperature produced by exposure to heat or sudden chilling resulting from too rapid evaporation of moisture from the surface of the body tend to predispose steel plant workers employed in the oven section of the coke plant, the casting section of the blast furnace, transportation of molten metal, stove and checker cleaning, open hearth repair, and tending soaking pits, furnaces or rolling mills.

Steel also suffers from several ills induced by excessive radiant energy. Heat exhaustion and heat stroke,—commonplace occurrences of the past, are now becoming so infrequent that they constitute only a potential threat to the present day steel mill worker. Nevertheless, it is well to recall that excessive drinking of alcohol, unusual fatigue, general debility, poor health and old age predispose to these conditions. Heat cramps in fatigued muscles, caused by loss of salt with excessive sweating and by the subsequent drinking of too much water appear most frequently among men of poor physique during the latter part of their working day. Dill has shown that individuals fortunately tend to become acclimatized to hot work by conserving their salt even while sweating freely. Iron and steel workers required to peer at molten or white hot metal also are prone to develop cataracts which appear characteristically in the optical center of the eye at the rear of the lens rather than at the periphery in the form of sectors or radii as noted in senility.

Dusts

THE steel giant has lived so long in an aura of soot and dust that it probably would go unrecognized by old acquaintances if given a clean face. The coke plant smirches its neighborhood with coal, coke and smoke, the sintering plant lies half concealed behind an enveloping cloud of greasy appearing hematite and during a "slip," blast furnaces cough tons of their charge of iron ore, limestone and coke into the surrounding air. In addition, dolomite and fluorspar at the open hearth, lime in the wire mill, coke breeze at the soaking pits, portland cement with the mason gangs and a host of other materials, each contribute their part to the overall dustiness of the steel works. Fortunately, these substances are practically inert when inhaled by workmen and are nuisances rather than serious menaces to health.

Though most of the grime surrounding the steel worker may be regarded with complacence, it must be pointed out that potently hazardous dusts also are encountered in certain parts of the plant. Refractory materials containing considerable proportions of dangerous free silica are widely used in the industry. At the bottom house materials composed almost entirely of free silica such as ganister, sand rock, river sand and broken silica brick are ground dry in large mullers with the production of high dust concentrations. At the open hearth and elsewhere throughout the plant many variations of dusty silica containing brick are unloaded by hand from railroad cars and stored in sheds prior to being used for building and repairing furnaces or for lining ladles. Finely ground dry ganister, fire clay and silica sand, alone and in combination are unloaded by crane from open gondola cars and stored in bins for the preparation of refractory cements or mortars. Laborers tear down highly siliceous open hearth furnaces and checker chambers with dry pneumatic drills and masons rebuild them with dry and dusty silica-containing brick. Laborers and masons are similarly exposed to silica dust in cleaning, repairing or reconstructing blast furnace stoves, the lining of a blast furnace, the refractory portion of power plant boilers, or the furnaces and soaking pits in a rolling mill. Kammer found more than one fourth of a group of steel plant masons were silicotic. The steel plant foundry also offers exposure to silica dust during such operations as sand preparation, shakeout, chipping and the cleaning of castings. Annealing at

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the sheet mill is also accompanied by silica dust evolved from the sand used to seal the trays in which the steel is housed. Men operating cranes in any of the departments which utilize or process silica containing materials are also exposed to a hazard from the fine dust carried to them by the ascending air. These observations indicate that the lungs of the steel giant are undoubtedly pigmented with inert dusts while here and there actual silicotic nodules also may be discerned.

Though steel's accustomed fare consists of carbon and iron it has of late years taken to diet rich in vitamins so that capsules containing copper, chrome, nickel, manganese, molybendum, silicon, lead, vanadium, tungsten, cobalt, zinc, tin, aluminum and many another metal may be found scattered about its habitat. Since some of these metals are poisons, it is apparent that a potential hazard may arise wherever they enter the manufacturing process. Time will not permit a discussion of each of the possible metal poisons but a few of the most interesting may be briefly described. One of the large steel companies recently patented a steel particularly suited to machining and made by adding molten lead directly to molten steel at the ingot mold. Lead fumes are created on the pit side of the open hearth during this operation and later both fumes and dust are evolved at the blooming mills where this steel is rolled. In fact one cannot fully comprehend all of the occupations threatened by this lead-containing product. Red lead is used extensively to spray and paint structural parts in steel mill shops and fabricating plants and molten lead baths serve to anneal steel wire. Lead containing metal is melted, poured and machined to form bearings for rolls and motor and scrap lead is reclaimed by melting in lead recovering furnaces. At each of these operations a potential lead hazard may develop for the steel mill worker.

Occasionally the blast furnace, tired of making pig iron, varies the monotony by turning out ferromanganese. During such periods, employees in this department may inhale the dusts from ores rich in manganese and capable of causing profound injury to the central nervous system. Brass foundry workers, welders and men working in hot galvanizing departments of steel plants have long been familiar with the extremely unpleasant symptoms of metal fume fever induced by the inhalation of freshly generated zinc oxide fumes.

Like most mechanical monsters, steel requires abundant lubrication. Over its articulated framework and into its cavernous belly must flow a never ending stream of oils, cutting compounds, greases and cleaning fluids. Many of these substances tend to dissolve the natural protective film from the workmen's skin, thus rendering it more susceptible to irritation and infection. Dermatitis is therefore commonly encountered wherever steel is machined as in the shops or bolt and nut departments or wherever it is cleaned, as in the pickling process which precedes galvanizing. It may also be recalled that coal tar, one of the materials definitely recognized as predisposing to skin cancer, is produced in large quantities at the steel mill coke plant.

The steel giant does not appear averse to the use of stimulants and, though it favors benzol over alcohol, will take trichlorethylene, carbon tetrachloride or other chlorinated hydrocarbons when offered. Benzol, one of the most hazardous organic solvents, is produced at the coke plant by the distillation of coal tar and enters the working atmosphere of that department at the scrubbers. Much more hazardous, however, are the other steel mill operations where this excellent solvent may find employment as a cleaning agent or vehicle for paints and cements. Certainly the electrical shops may be expected to use benzol and all departments producing painted articles will bear careful scrutiny. Trichlorethylene makes its appearance in the units installed for degreasing steel. This extremely toxic chlorinated hydrocarbon possesses the additional nasty habit of decomposing in an open flame to form phosgene—one of the well known poison gases.

This giant, like those of legend, breathes fire and hot gases. Even though engineers have done much to ensnare the flames, gases and heat of the steel industry, an occasional molecule of carbon monoxide or a stray British Thermal Unit can be found at large around a modern blast furnace. Since carbon monoxide has over 200 times more affinity for hemoglobin than oxygen, concentrations of this gas as small as 0.02% may induce serious symptoms after a few hours continuous exposure. The steel worker is threatened not only with carbon monoxide, which is forever trying to escape its bondage, but also in certain confined areas with gases such as the nitrous oxides or ozone generated by electric arc welding or Cottrell precipitators for removing dust. It is also worthy of note that dangerous concentrations of arsine may be met in cleaning out the sludge from pickling tanks.

Even though steel is huge, it is not a clumsy fellow. The latest report of The National Safety Council shows that the frequency rate for disabling injuries has been reduced to slightly more than six per million man hours—third lowest of all the industries tabulated.

What conclusions may be drawn from the examinations of this giant? It appears to be a hot tempered, though extremely likable, fellow just past the carefree age of youth, still powerfully strong and vigorous but with several early defects and bad habits which, if not soon corrected, may lead to serious trouble—such as an expensive trip to the hospital for the removal of some badly damaged part. It is a grimy, noisy and good natured monster with the hypochondriac's tendency to take any new pills appearing on the market regardless of the state of health enjoyed at the time.

The findings suggest that it would be much more reasonable to place this giant in skilled hands now, in order to assure its continued health, than to await some disabling illness before starting treatment. Every steel mill should have a division of industrial hygiene. This department should include a carefully balanced engineering and medi-

cal personnel working together to detect and control the hazards of the industry. The function of the engineering branch of this partnership should be to determine the degree of exposure to all potential hazards, while the medical section should seek to ascertain the degree of each individual steel mill worker's susceptibility to the threatened dangers. Control of occupational hazards in the steel plant may then be accomplished by either or both of the divisions in this department.

Engineers should calm the volatile temper of the giant with such inducements as properly directed air currents at hot working places, protective screens, suitably selected clothing and carefully tempered showers. Harmful exposure to silica dust or other poisons may be reduced by substituting wet methods for dry, by applying well designed exhaust ventilation or by utilizing personal protective equipment. The engineer also should act as nursemaid and bodyguard, keeping the giant out of too much oil, alkali or acid, noting that it keeps reasonably clean, that it does not go on a benzol or trichlorethylene binge, that it does not venture recklessly into an atmosphere containing poison gases, meanwhile warning it always to remember "safety first."

The physician should give this Gargantua a complete examination at regular intervals in order to warn it of any defects or diseases, so that it may seek treatment before permanent disability is incurred. The physician also should supervise the salt and water intake when the giant's work is hot, should x-ray its chest when exposed to silica, should determine the amount of lead excreted in the urine or the degree of basophilic stippling of red blood cells following contact with this heavy metal, prescribe protective creams when dermatitis is observed, ascertain the proportion of organic and inorganic sulphates in the urine when benzol has been imbibed too freely, discover the degree of saturation of the blood with carbon monoxide after exposure to this gas and constantly guard the giant against contracting infections.

If the suggestions which have been offered are followed, the giant should enjoy a long and healthy life and should be a good risk for health insurance at the normal premium rate.

Industrial Hygiene Procedure

—For Effective Occupational Disease Control—

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THE various phases of industrial hygiene and occupational disease investigations cover a wide field. The most complete and detailed studies require the coordinated efforts of experts in several professions. Examples of such work are the many studies carried out by the United States Public Health Service, such as the investigation made in West Virginia on silicosis and lead poisoning among pottery workers. Personnel of both the Public Health Service and the State Division of Industrial Hygiene cooperated in the work. Scientific workers taking an active part in this study were physicians experienced in occupational diseases, roentgenologists, clinical laboratory technicians, industrial hygienists, chemists, mineralogists, and a technical editor assisted in editing the report. However, such large scale and detailed investigations are usually confined to Federal and state health groups. No doubt, most of you present are primarily interested in one particular company, which, except in a few cases, does not consist of more than one factory.

It is probable that often your first knowledge of an industrial hygiene problem in your particular factory arises when Bill Smith from Department 26 walks into the first aid room or medical department and says, "You know, I don't feel very good. I'm not really sick either, but I don't feel as well as I used to and I've been wondering if that stuff I work with may have a bad effect on me" You know that Bill has worked with this material for two or three years and that others use it in the factory too, but you have heard of no trouble before. It is important at this point of the problem not to permit yourself to get the idea that just because such a condition never has occurred before in your factory, "it can't happen here." Ordinarily you would consider wax to be a harmless material, yet the vapors from some particular types of wax have been proved to be very toxic. One might say a dental laboratory worker could never get silicosis from his work but it actually has happened according to medical findings corroborated by autopsy.

Consequently, the best method to follow is to make a thorough investigation to determine as nearly as possible exactly what the situation is. When faced with a special situation the commander of a military unit makes what is termed an "estimate of the situation." He calls his staff together, outlines the situation and each member, who is a specialist or expert in some particular phase of the miltary establishment, is expected to investigate and report back to the commander who then makes his decision as to the plan of action after considering all of the expert reports. A specific case in industry concerned a gas which was causing irritation to eyes and upper respiratory tract of several workmen. A time was set and the superintendent in charge of production, the medical man, the safety man and the industrial hygiene man all witnessed and discussed the operation as a start of the investigation. It is evident that each of these men has a different point of view but all have the same objective and coordination of effort enhances the possibility of reaching the goal. The logical procedure was then to determine the nature of the gas, the concentration in the workers' breathing zone, and whether

Presented at the Industrial Hygiene Session of the Midwest Safety Conference, at Chicago, May 2, 1940.

under the conditions existing there was a hazard to health. This work requires help from all of those mentioned and possibly others when special examinations or analyses must be made by experts.

Having assembled all this information the "staff" then reports back to the commander, in this case the production superintendent, presents him with the facts and makes suggestions as to what courses may be followed. The superintendent must then make his decision as to the proper action to take.

As the size of an army unit becomes smaller, the number of experts in the commander's staff is reduced until the number may become only one or two. Likewise in industry, in relatively small organizations there may be only one or two to assist the production superintendent. Nevertheless, the same rule should apply. As complete an investigation should be made as possible. It will then be apparent to the superintendent whether or not further facts must be determined. If more information is required, then he must call in expert help from some outside source. In this manner sufficient information is obtained to enable the superintendent to make a wise decision in the course of action to be taken.

In one small plant, the vice-president in direct charge of production operations was apprized of the fact that a rubber cement being used by five women contained benzol as the solvent. The vice-president called the foreman for this group of women and discussed the question with him. There were no others present in the factory having expert knowledge which would have been of assistance in this problem. The vice-president and foreman decided to purchase two or three other types of adhesive for trial, making sure that none of the trial products contained benzol, and soon a satisfactory rubber cement was found. In this case, however, the vice-president was not satisfied since the trial product contained a petroleum distillate and he wished to go even further. Eventually he found an adhesive containing neither benzol nor petroleum distillates, which was perfectly satisfactory for his application, and he has been using that material ever since. This is an example of good industrial hygiene procedure in a small factory.

When an industrial hygiene problem arises then, the plan of action is to make a thorough estimate of the situation and make a decision as to the course to follow in the light of the facts determined. This may seem self-evident but the importance of a careful investigation can be easily overlooked. It is quite possible for a cursory investigation resulting in erroneous conclusions to be more harmful than no investigation.

To determine the facts in a particular problem is not always easy. Many things must be considered and each individual operation in a factory is a problem in itself. Impaired health may, of course, be caused by a non-occupational condition or exposure, but a worker's complaint should not be disregarded on this possibility until an investigation has been made. Just because a given type of operation presents a health hazard in one particular factory, it cannot be assumed that in another factory where conditions are different, the operation is hazardous also. A degreasing operation illustrates this point. In one factory a "home-made" equipment had been constructed for degreasing metal parts using carbon tetrachloride as the solvent. All conditions combined to produce a very real health hazard for men doing this work. Carbon tetrachloride has the lowest boiling point of any of the commonly used chlorinated hydrocarbon degreasing materials and in this case the metal parts were hot when dipped. As a result rapid vaporization of the solvent occurred. No drain racks had been constructed so that liquid solvent was spread over a large area as it drained from the parts which had been placed on a flat table. This, too, was conducive to rapid vaporization. No exhaust ventilation had been installed, and consequently, the vaporized solvent diffused through the general workroom air, exposing the degreasing workman to the greatest concentration and other workers nearby to lower concentrations. On the other hand, many factories use carbon tetrachloride and similar materials in well-designed equipment which accomplishes effective control of the vapors and under such conditions there is but little health hazard. It is not implied that every investigation will require considerable time and painstaking detail. Each case is an individual problem and good judgment must be used in order to determine how much and what kind of information is necessary in order to properly evaluate the hazard.

In the usual investigation the concentration of the potentially hazardous material in the air at the workers' breathing zone is one of the more important facts to be determined. In this field, training and experience are as beneficial to the investigator as in other special fields. There is considerable opportunity for expert judgment as to the methods to be used, number of determinations to be made, time and place of sampling, type of equipment to be utilized in the sampling and in fact, to determine whether or not sampling is necessary.

Methods of dust sampling are quite well established but experience is necessary for accurate enumeration. Analysis to determine the composition of the dust itself requires expert knowledge. Some types of gases and vapors require very technical and elaborate chemical analyses for determination. For several of the gases and vapors, special instruments have been developed to determine concentrations directly by drawing a sample of the air containing the material in question through the instrument. When using even the simplest of these instruments, it is desirable to be as familiar as possible with the details and characteristics of operation. With the MSA Hydrogen Sulphide equipment, directions are given to make ten squeezes of the aspirator bulb, and then make a reading. One might, under some conditions, decide to use 40 squeezes of the bulb and divide the

result by 4, in order to get greater accuracy for low concentrations. However, this procedure would introduce a large factor of error. There is continuous investigation being carried on to develop methods and equipment for sampling. The objects sought in this work are relatively simple methods with sturdy equipment, short analyses with reasonable accuracy and methods that are specific for given materials.

All of the senses of the investigator may be utilized since most of them are useful in the average investigation. The sense of smell is often of especial benefit. The nose is extremely sensitive and numerous gases and vapors may be detected in concentrations less than 1/10 of 1 part per million. Ozone and a large group of sulfur compounds are in this category. Various solvents can sometimes be identified by this sense only, benzol for example. Hydrocyanic acid gas can be judged by some persons more by the sense of taste than by odor.

There are two points which should receive especial emphasis in connection with the sense of smell. First, in accordance with well-recognized physiological laws this sense dulls very rapidly on sustained exposure to an odor. Consequently, the intensity of an odor must be judged when it is first detected. Secondly, caution must be used in the inhalation of the more toxic gases such as hydrocyanic acid and hydrogen sulfide. This is not only because of the extremely toxic nature of these gases but because of the decreasing sensitivity of smell.

Besides concentration values other facts which must be determined when investigating an operation are the total time of exposure in a given period of time, whether the exposure is to high concentrations for short periods of time, to low concentrations for long periods of time, or some combination of the two. Also, the manner in which the operation is carried out by the workman is important. One reason for this is to determine what possible ways the material may enter his body. It must be known, of course, how the material in question can enter the body. Hydrocyanic acid gas, for instance, may be absorbed directly through the unbroken skin. Silicosis results from dust entering the body by inhalation. Several cases of lead poisoning have occurred in children due to ingestion of lead obtained from the paint on toys or on woodwork such as their beds. Sickness from ingestion of toxic materials is not common in industrial workers. Some materials may be absorbed into the body by all three means of entry. For example, lead tetraethyl may be inhaled, absorbed through the skin, or ingested, although only the first two methods are of importance. And finally, medical examination of the persons who perform the operation may give some indication of the degree of hazard existing.

The conditions surrounding each case must determine how much and how detailed the factual information must be. After the necessary facts are obtained and properly correlated, the decision must be made as to whether the operation is hazardous, and, if it is, what action should be taken.

Substitution of a less hazardous material should always be considered, even though it is not frequently applicable. In some cases, where it can be done, it presents a simple solution to the problem. Usually some method of control must be worked out. This often takes the form of properly designed ventilation or exhaust equipment. A general statement can be made to the effect that any material can be safely used by utilizing proper control measures. There are very few exceptions to this rule.

AT THIS point I shall consider a not uncommon problem arising when an investigation of a potentially hazardous operation has been completed. The material in question is known to be toxic in some concentration. The results of the investigation indicate that when considering all factors there is probably no hazard under ordinary conditions but under other conditions there probably is some hazard for varying periods of time. In other words, it is a borderline case. I have intentionally used the word "probably" because in such cases it is absolutely impossible for the industrial hygienist or the physician to say positively and definitely that the worker's health will or will not be harmed some time in the future. When this situation occurs, the question arises as to whether or not an expenditure should be made in order to definitely control the hazard. This is a question which should be faced squarely and if necessary, referred to the management for decision. In such a case, the company policy and general attitude of the management toward the employees usually will decide the issue.

This management problem is not greatly different than some others. For instance, an investigation reveals that by the expenditure of $10,000 for a special machine the company can show a bigger profit on a given product. On the other hand, should the contract for that product be canceled any time within a year after the purchase of the machine, the machine would be useless and would represent a loss to the company. A decision must be made whether or not to buy the machine and problems of this nature containing an element of chance are common in the modern industrial world.

In borderline health hazard cases the element of chance is present also. Most will agree that it would be highly desirable to reduce the potential health hazard to a minimum when considering the worker's point of view. However, aside from that the employer has a good chance of making a profit on his investment which produces cleaner and healthier conditions. Healthy satisfied workers reduce labor turnover and constitute a very valuable asset to any company. Profits from this kind of investment may be somewhat intangible but nevertheless they are very real and many companies are spending large sums of money for improvement of general working conditions.

Up to this point, the procedure described applies to the handling of an industrial hygiene problem which was first learned about by a complaint on

the part of a workman. You will agree, I am sure, that this is not the ideal situation. The ideal way to handle the matter would be for those responsible for the health of employees to initiate a thorough survey of all factory operations, and correct such conditions as were found hazardous before any trouble occurred. Whenever a new operation was to be started, it should be thoroughly investigated from the industrial hygiene angle and any necessary control measures installed at the beginning. In most cases periodic checks must be made to insure that operations are performed in the proper manner as decided on originally and that hazardous materials remain properly controlled. It should be emphasized that industrial hygiene control work is a continuing process. Problems arising because of new materials, new processes and maintenance work require continued effort in order to assure an effective control program.

The New Allison Division Plant of General Motors is an outstanding example of the ideal approach to industrial hygiene problems. The health and the comfort of workmen were considered to be of the greatest importance. Consequently, the factory was planned to include numerous features which would produce the best of working conditions. The factory is completely air-conditioned, artificially lighted and is equipped with ample modern sanitary facilities. Especial attention has been given to dust control equipment and adequate illumination of the best type. Undoubtedly, it was necessary to meet several requirements when consideration was given to the plans for this plant. Nevertheless, it is obvious the management believed that an expenditure of considerable size was warranted for the purpose of obtaining the best working conditions as known today.

Assuming that reasonably effective industrial hygiene procedure exists in your factory, what should you expect as a result? First of all, and of great importance, the worker will benefit by enjoying better health and prolonged working life at higher efficiency. He will be better able to support his immediate family and help others who may depend on him. The employer will benefit by reduced operating expense, less labor turnover, and in many cases, lower direct production costs. Another benefit accruing to the employer is the increased feeling of satisfaction with his job, on the part of the employee. This condition can be of a great deal more importance than it might seem at first thought. The community in which the factory is located will benefit by having healthier and happier workmen in its midst.

In closing, I should like to leave this thought with you. Industrial hygiene and occupational diseases are seldom as dramatic in their action or results as are accidents. Silicosis may be developing in a man over a period of 15 years and during most of that time he may feel no ill effects. Yet, when this man finally experiences a definite advanced stage of silicosis, he is ready for very serious and sometimes dramatic results from both the physical and economic standpoints. Many of the occupational diseases are of this subacute or chronic type and difficult of exact diagnosis. Because of this, there is a tendency to give but scant attention to a workman, not seriously sick, but whose health is below normal as a result of his employment. However, such workers constitute a problem of significant magnitude when consideration is given to the many ramifications of the situation. Therefore, the development of effective industrial hygiene procedure in your factories merits your sincere efforts to the end that your workmen may expect to have as good health and as long a working life as those employed in non-industrial pursuits.

Toxicity

—*of Heat-Converted Films of Urea-Formaldehyde-Ethylene Glycol Resins Taken Orally*—

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Reichhold Chemicals, Inc.,
Detroit, Michigan

INDUSTRIAL USES:

Urea - formaldehyde - ethylene glycol resins have been made for industrial purposes for some time. However, when paper-coating compositions were proposed for grease-resistant wrappers coming in contact with foods such as butter, lard, meat and other fatty substances, it was deemed necessary that toxicity tests be carried out in a manner which would be commensurate with the amount of material which might be consumed orally. Other industrial uses to which these products may be applied are as plywood adhesives, fabric stiffeners, and in combination with rubber latex. In general, these resins, while initially water-soluble, are to be used after application of heat in order that the final film is of an insoluble, infusible gel structure. Resins of this type were described by the authors,[1] emphasizing their stability in solution in storage prior to their use and subsequent conversion by heat to the insoluble, infusible form.

II. RESIN COMPOSITION:

In the preparation of this resin, the following materials are employed:

Aqueous Formaldehyde (37%) (3 mols)	243 parts by wt.
Water	150 parts by wt.
Ethylene Glycol (1 mol)	62 parts by wt.
Urea (1 mol)	60 parts by wt.
Ammonium Hydroxide (26%, Sp.Gr., 0.90)	5 parts by wt.

These are refluxed for 30 minutes at boiling in a glass-lined kettle equipped with a reflux condenser, steam and water jacket, and an agitator. The resulting water-white stable resin solution is then thinned down to 40% non-volatile content with water and cooled to room temperature as rapidly as possible to maintain a low viscosity in order to promote penetrating power. The manufacturer of these resins has been described in several patents by the authors.[2,3,4]

Presented at the First Annual Meeting of the AMERICAN INDUSTRIAL HYGIENE ASSOCIATION, New York, June 4, 1940.

III. General Study of the Problem from the Standpoint of Acute and Chronic Toxicity:

In a study of the toxic properties of a material, it is necessary to take into consideration both acute and chronic toxemia. Therefore, this experiment is divided into two different tests to cover the above factors.

Acute toxemia usually is the result of the ingestion of a single relatively massive dose while chronic toxemia is the result of the ingestion of smaller doses over periods of time. This being the case, it is necessary to include two separate tests, one of which provides for a single massive dose and the second, for smaller doses over a period of time. The relative amounts of the test material fed in each case is governed by a consideration of its chemical and physical characteristics, its intended purpose, as well as any available information on its toxic properties.

Since the product is to be used for waterproofing paper for wrapping foods, and in view of its extremely low solubility, it is improbable that any appreciable amount of the material would contaminate the food or be ingested.

Owing to this factor of low solubility, and the intended use, it was impossible to estimate how much of the material might be ingested in actual practice. Therefore, empirical dosages for both acute and chronic toxicity were used which we believe are many times those which could possibly be consumed under any condition.

Guinea pigs were used for the acute test since they are extremely sensitive to toxic agents. Rats, on the other hand, were chosen for the chronic test because of the similarity of their digestive tract to that of a human and thus they would be comparable to humans on a basis of body weight. Also, by taking two species, information as to possible species differences in sensitivity would be available. The weights of the animals are obtained at the start of the test, and again at the end. Likewise, at the end of the test period, the animals are sacrificed and carefully autopsied for any pathological changes.

Since the sample submitted was a solution containing a solvent which might be toxic, the solvent was evaporated. The residue was dried in the oven at 100° C. until its weight was practically constant. The transparent brittle residue was finely powdered and used in the toxicity tests.

IV. Experimental Data—Part 1:

A group of 10 guinea pigs weighing approximately 300 grams were selected for this experiment to determine the effect of a single relatively massive dose of the test substance.

One hundred milligrams of the material was powdered and fed in 2 grams of the feed per animal. This dose was considered as many times that which could possibly be ingested by a human under actual conditions on an equivalent weight basis. Weights were taken at the start and finish of the test. After holding the animals for 14 days, which period was considered ample for the development of any toxic symptoms, they were sacrificed for any gross pathological changes. Histopathological studies were also made on three representative animals to confirm the gross findings.

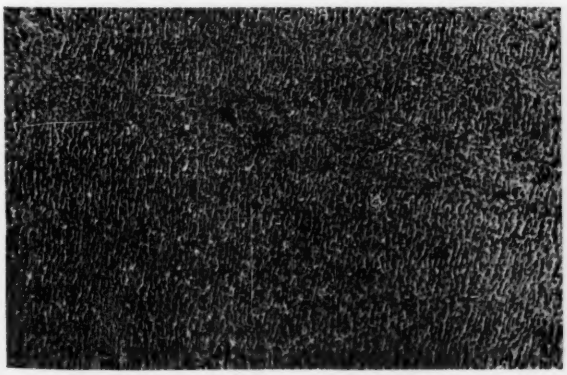
TABLE I
Weights In Grams

Guinea Pig Number	Weight at Beginning	Weight at Sacrifice	Gain or Loss
850	328	358	+30
851	339	342	+ 3
852	310	316	+ 6
853	344	353	+ 9
854	319	347	+28
855	302	328	+26
856	325	370	+45
857	304	349	+45
858	292	337	+45
859	302	329	+27
Average	316.5	342.9	+26.4

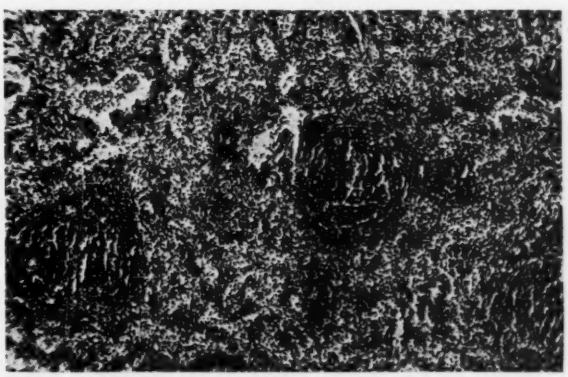
TABLE II
Gross Pathological Observations of Individual Animals Sacrificed at 14 Days

Guinea Pigs

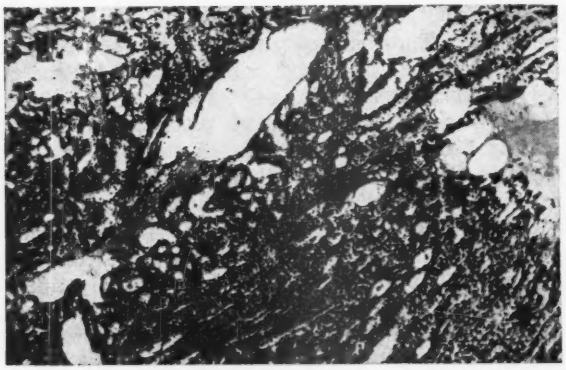
No. 850. Abdominal muscles red. Small amount of visceral fat. Small intestine slightly hyperemic.
No. 851. Abdominal muscles red. Small amount of visceral fat. Small intestine slightly hyperemic.
No. 852. Abdominal muscles slightly red. Small intestine hyperemic.
No. 853. Abdominal muscles somewhat red. Small intestine slightly hyperemic.
No. 854. Abdominal muscles red. Small intestine hyperemic.
No. 855. Abdominal muscles slightly red. Small intestine hyperemic.
No. 856. Abdominal muscles slightly red. Small intestine hyperemic.
No. 857. Normal. No. 858. Normal. No. 859. Normal.



Guinea pig No. 851. Section of adrenal showing normal cellular detail

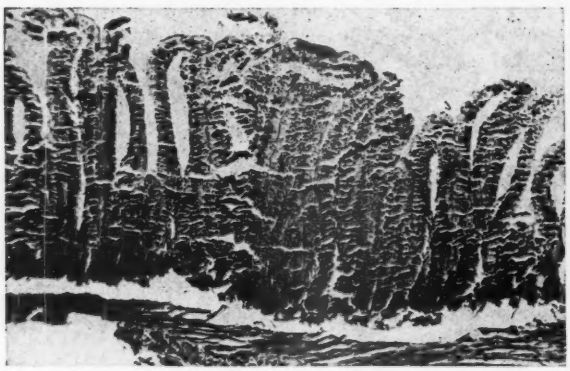


Guinea pig No. 858. Section of spleen showing only normal histological detail

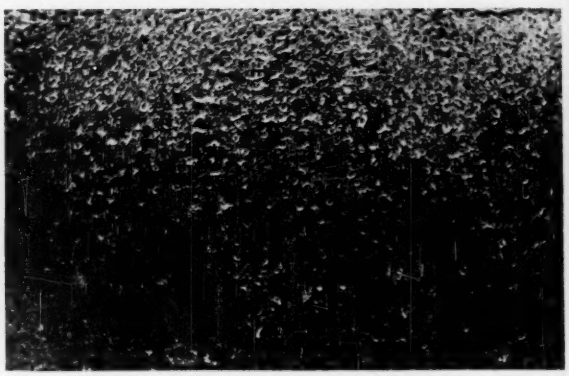


Guinea pig No. 858. Section of kidney revealing normal cytological detail

Guinea pig No. 858. Section of stomach showing mild irritation of the mucosa



Guinea pig No. 858. Section of intestine revealing normal characteristics



Guinea pig No. 858. Section of liver revealing normal cell characteristics

TABLE III

HISTOPATHOLOGY OF REPRESENTATIVE ANIMALS SACRIFICED AT 14 DAYS

GUINEA PIGS

No. 851.	LIVER—Kupffer cells active. Vacuolation of the cell cytoplasm.
	SPLEEN—Malpighian bodies normally defined. Cellular detail normal.
	KIDNEY—Swelling of tubular epithelium and occasional shrinking of the capillary tufts.
	GASTRO-INTESTINAL TRACT—No pathology.
	ADRENAL—Cellular characteristics normal.
No. 855.	LIVER—No pathology.
	SPLEEN—Normal cellular detail.
	KIDNEY—Normal.
	GASTRO-INTESTINAL TRACT—Normal.
	ADRENAL—Normal.
No. 858.	LIVER—Normal. SPLEEN—No pathology.
	KIDNEY—Normal.
	GASTRO-INTESTINAL TRACT—Small areas of pseudomembrane formation noted in the stomach.
	ADRENAL—Normal.

TABLE IV

SUMMARY OF GROSS AND HISTOPATHOLOGICAL OBSERVATIONS

GUINEA PIGS

Gross observations of the organs of the animals sacrificed at 14 days after receiving the test product showed little significant pathology. The abdominal muscles were red and the small intestine was hyperemic in nearly all animals.

Histopathological studies of the organs revealed vacuolation of the cytoplasm in the liver of one animal. The kidney revealed swelling of the tubular epithelium and shrinking of the capillary tufts in one instance. Slight inflammation of the stomach muscosa was noted in one animal. Diagnosis: No acute toxemia.

PART 2:

A group of 10 rats weighing approximately 200 grams each were selected for this experiment to determine any chronic effects of the test material when fed daily over a period of time. Ten milligrams of the material were dissolved in alcohol and further diluted in orange juice to provide an alcoholic content of not over 30%. Alcohol was necessary as a solvent since the material otherwise would not have gone into solution. Each animal received 0.2 cc. of this solution daily for 30 days. This dosage was considered more than a human could consume under actual conditions on an equivalent weight basis even over a period of time. Weights were taken at the start and again at the end of the experiment.

At the end of 30 days, all the animals were sacrificed and gross autopsies performed to determine any effects of the test material when ingested daily

TABLE I

WEIGHTS IN GRAMS

Rat Number	Weight at Beginning	Weight at Sacrifice	Gain or Loss
1	214	240	+26
2	226	247	+21
3	186	186	0
4	206	228	+22
5	185	196	+11
6	187	256	+69
7	214	Died 7th day	
8	223	286	+63
9	224	298	+74
10	197	250	+53
Average	206.2	243.0	+33.9

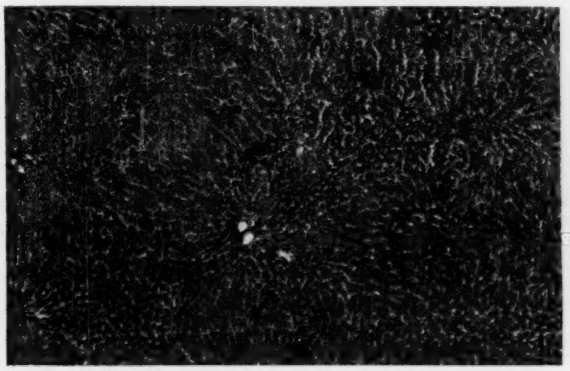
for such a length of time. Histopathological studies were made on the visceral organs of three representative animals to supplement the gross findings.

TABLE II

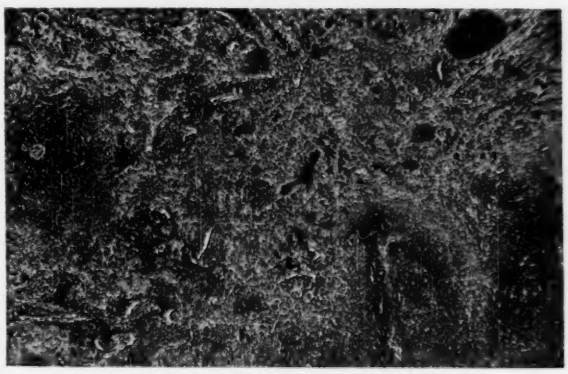
GROSS PATHOLOGICAL OBSERVATIONS OF INDIVIDUAL ANIMALS SACRIFICED AT 30 DAYS

RATS

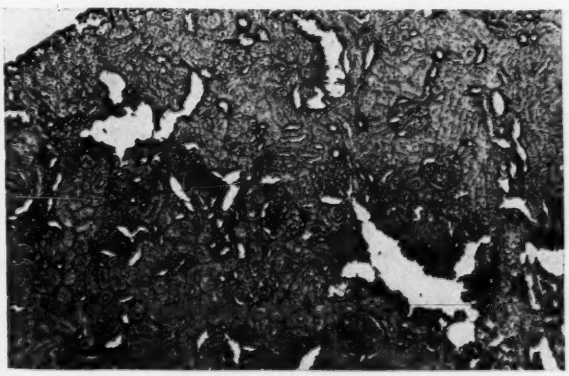
No. 1. No pathology present.
No. 2. No pathology present.
No. 3. All organs normal with the exception of the lungs, which show the presence of pneumonia.
No. 4. Small intestine hyperemic. All other organs reveal normal characterisitcs.
No. 5. Lungs slightly hyperemic.
No. 6. Spleen slightly darker than normal.
No. 8. Spleen dark in color.
No. 9. Abdominal muscles red.
No. 10. Small intestine hyperemic. Kidney slightly swollen with dark cut sections. Lungs congested.



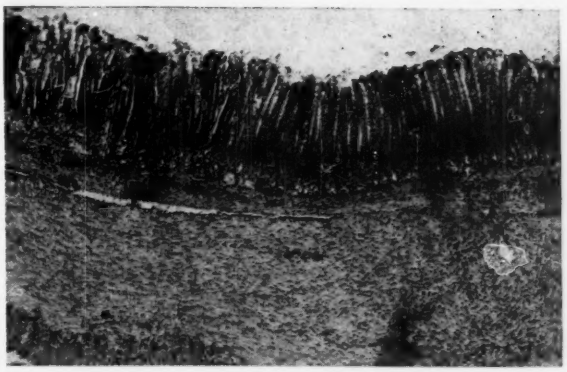
Rat No. 1. Section of liver showing mild confluence of the cell cord cytoplasm



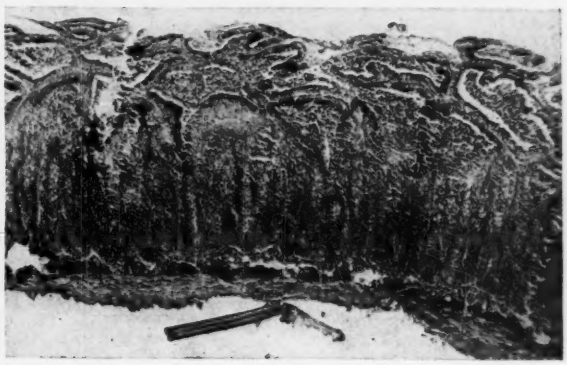
Rat N.o 1. Section of spleen showing pigment deposits



Rat No. 1. Section of kidney showing incipient necrosis of the cortex



Rat No. 1. Section of stomach showing normal detail



Rat No. 1. Section of intestine showing normal detail

TABLE III

HISTOPATHOLOGY OF REPRESENTATIVE ANIMALS SACRIFICED AT 30 DAYS

RATS

No. 10. LIVER—There is marked confluence of the cell cytoplasm and fading of the nuclei. Kupffer cells are abundant.
SPLEEN—The Malpighian bodies are poorly defined. There is marked amounts of dark pigment.
KIDNEY—Areas of glomerular swelling. Cloudy swelling of the convoluted tubules.
GASTRO-INTESTINAL TRACT—Very mild inflammation of the stomach mucosa. There is marked inflammation of the intestinal mucosa.

No. 1. LIVER—Mild confluence of the cellular cytoplasm. Kupffer cells noteworthy.
SPLEEN—The Malpighian bodies are well-defined. Pigment deposits are noteworthy.
KIDNEY—Incipient necrosis of the cortex evidenced by swelling of the glomeruli and convoluted tubules with marked fading of the nuclei.
GASTRO-INTESTINAL TRACT—The stomach and intestine show normal characteristics.

No. 8. LIVER—Confluence of the cell cord cytoplasm. Kupffer cells noteworthy.
SPLEEN—Malpighian bodies well-defined. Pigment deposits slight.
KIDNEY—Incipient necrosis of the cortex evidenced by swelling of the convoluted tubules and degeneration of the nuclei as well as merging of the glomeruli with the capsule wall.
GASTRO-INTESTINAL TRACT—The stomach and intestine show only normal characteristics.

No. 3. LIVER—Mild confluence of the cell cord cytoplasm.
SPLEEN—The Malpighian bodies are poorly-defined. A large number of lymphoid cells may be observed.
KIDNEY—The glomeruli merge with the capsule wall and the convoluted tubules are swollen.
GASTRO-INTESTINAL TRACT—The stomach and intestine show only normal characteristics.

TABLE IV

SUMMARY OF GROSS AND HISTOPATHOLOGICAL OBSERVATIONS

RATS

Gross pathological observations of the organs of rats sacrificed at 30 days showed little significant pathology. Two animals revealed hyperemia of the small intestine. Lung congestion was also observed but this was in all probability not an effect of the material ingested.

Microscopic examinations of the organs revealed confluence of the cellular cytoplasm in the liver. The malipighian bodies of the spleen were poorly-defined in two instances and pigment deposits were present. There was swelling of the convoluted tubules in the kidney and merging of the glomeruli with the capsule wall. In one animals the stomach and intestinal mucosa was inflamed.

Diagnosis: Mild toxemia.

V. DISCUSSION OF RESULTS:

Tests on guinea pigs, in which 100 milligrams of the material were fed in a single relatively massive dose, with their sacrifice 14 days later, showed the material to be non-toxic. This conclusion was based on the gain in weight while on test, their general appearance, and the result of pathological studies following autopsy.

Tests on rats, in which 10 milligrams of the product were fed daily for 30 days, showed from autopsies very little significant toxemia but upon microscopic studies mild gastro-intestinal irritation as well as mild effects upon the liver and kidney could be noted.

However, after careful consideration of the above data, especially in view of the nature of the product, as well as the purpose for which intended, it can be safely concluded that no toxic effects would result from its use in actual practice.

VI. ACKNOWLEDGMENT:

We wish to thank H. Reichhold for kind permission to publish this article, and to acknowledge that the experimental toxicity work was done under the direction of Dr. Harvey A. Seil, of Seil, Putt and Rusby, Inc., of New York.

Literature Cited:

1. HODGINS and HOVEY, *Ind. & Eng. Chem.*, 31, 673-8 (1939).
2. *Ibid*, U. S. Patent 2,168,477 (Aug. 8, 1939).
3. *Ibid*, British Patent 514,058 (Oct. 30, 1939).
4. *Ibid*, U. S. Patent 2,185,167 (Dec. 26, 1939).

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